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INDIANA UNIVERSITY

A Measure of Motor Fitness for College Men

by
KARL W. BOOKWALTER
and
CAROLYN W. BOOKWALTER

A List of Bulletins in the Field of Education
Indiana University
by
KATHLEEN DUGDALE

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A Measure of Motor Fitness for College Men

KARL W. BOOKWALTER AND CAROLYN W. BOOKWALTER

INTRODUCTION

THE purpose of this study is to determine an index of motor fitness for adult males of army and college age. This measure must be administratively feasible with lay help, with a minimum of time, and with a minimum requirement of equipment and previous training of participants. By motor fitness is meant the ability to exert reasonable strength, speed, and fundamental skills of large muscle type over reasonable periods of time. Motor fitness also includes endurance and efficiency as determined by performance in related activities in comparison with norms for comparable individuals. Diseases, or visual, auditory, dental, or glandular defects are not considered except as the motor fitness may reflect them. Specialized athletic, artistic, or vocational skills are not assumed to be measured by a test of motor fitness.

The need for such a measure is evidenced by the many demands from the training centers for the armed forces for some simple measure of improvement in the motor fitness of trainees. Other studies are being made contemporaneously with the present one by such workers as McCloy and Cureton, using various approaches. The needs for the evaluation of the intensified "physical fitness program" for men at Indiana University made possible a dual function of the measurements involved in this study.

A survey[1] of previous factor analysis studies, as indicated in Table I, reveals some 15 factors related to successful performance in physical education activities. The fourth ranking item, a culmination of large muscle coordination and motor educability, in Table I, is justified by the similarity of the elements involved in each of the several studies involving the two factors.

A study by Cozens[2] of general athletic ability and a recent study of motor fitness by Cureton[3] emphasize the factors of endurance, power, and agility.

Any factor isolated in any one study leaves a residual relationship, or the total relationship of the criterion is reduced by the contribution of the first factor to the total group. Hence, order of isolation (determined by the degree of relationship to the total battery) is a criterion for judging the validity of any factor in this analysis of factor analyses. Two criteria are empirically weighted

[1] Bookwalter, Karl W. "A Survey of Factor Analysis Studies in Physical Education." *The Physical Educator* 2:209-12, June, 1942.

[2] Cozens, Frederick W. "The Measurement of General Athletic Ability in College Men." *University of Oregon Publications*, Physical Education Series, Vol. I, Eugene, April, 1929. pp. 126-91.

[3] Cureton, Thomas K. *Inventory of Motor Fitness*. Physical Fitness Clinic, University of Illinois, December, 1941. 16 pp., mim.

equally in the determination of final selection and order of importance for the present study, namely:

1. Order of isolation of the factor in each study
2. Frequency of isolation of the factor

By these criteria it can be seen in Table I that strength, velocity, dead weight, motor educability, height, and endurance are the most important factors related to success in physical education activities as evidenced by this study of factor analysis studies. These ranks are shown in the final column (headed "Rank") in the table.

TABLE I. FACTORS INVOLVED IN SUCCESS IN PHYSICAL EDUCATION ACTIVITIES AS REVEALED BY FACTOR ANALYSIS STUDIES*

Factors	Studies																Order of isolation	Frequency of isolation	Rank
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
Abdominal strength								4									4	1	
Agility				1													1	1	
Arm strength					5										4		4.5	2	
Balance				4													4	1	
Dead weight	3	3	4		2	2							3		5		3.1	7	3
Dynamic strength								1	2	1							1.3	3	
Endurance				3										3			3	2	6
Flexibility				5													5	1	
Height or structure			3			4									3		3.3	3	5
Motor educability							1		3		4					3	2.8	4	
Big muscle coordination								3	1		3	3					2.5	4	4
Muscular latency															6		6	1	
Power				2													2	1	
Sensori-motor coordination																4	4	1	
Speed		2												2			2	2	
Static strength								2		2							2	2	
Strength (force)	1	1	1	6	3	1	2				1	1	1	1	1	1	1.6	13	1
Velocity	2		2		1	3		4			2	2	2		2	2	2.2	10	2

* Table I, above, is read horizontally as follows: abdominal strength was isolated in study number 8 and was the fourth factor isolated in that study. That is the only study revealing abdominal strength as a factor, hence its frequency of isolation was 1. It does not merit a rank among the more important factors therefore.

Reading Table I vertically, it can be seen that study number 1 has isolated dead weight, strength, and velocity in the order 3, 1, 2, respectively.

Guided by these several studies, the following factors have been somewhat empirically chosen for the criterion factors in this study: (1) strength, (2) velocity, (3) dead weight, (4) motor ability, (5) height, (6) power, (7) endurance, and (8) agility. Elements to be measured for the criterion have been chosen because of their evidenced contribution to one or more of these factors, and some measure of each factor has been included.

THE CRITERION OF MOTOR FITNESS

The criterion of validity of items as measures of motor fitness for this study consists of the sum of modified T-scores of 20 events. Most of the events have elsewhere been shown to be related to one or more of the factors chosen above. The items (tests or measures) and the factors to which they are known or assumed to be related are:

I. Strength
   1. Chins
   2. Dips (on parallels)
   3. Larson Dynamic Strength Test
   4. Push-ups

II. Velocity
   1. Vertical jump
   2. Standing broad jump
   3. 60-yard dash
   4. 440-yard run

III. Dead Weight
   1. Weight
   2. Classification Index I

IV. Motor Ability
   1. Brace test (Iowa Revision)
   2. Burpee test
   3. General Motor Capacity
   4. General Motor Quotient

V. Height
   1. Height
   2. Classification Index I[4]

VI. Power
   1. Classification Index I
   2. Chins-plus-dips times vertical jump
   3. Chins-plus-push-ups times vertical jump
   4. Standing broad jump
   5. Vertical jump

VII. Endurance
   1. 440-yard run
   2. Two-mile walk
   3. Drop-off (Time on 440-yard run divided by time on 60-yard dash)
   4. Chins
   5. Dips

VIII. Agility
   1. Burpee test
   2. Vertical jump
   3. Standing broad jump

Age has also been included, since it is employed in Classification Index I. In this study each of these items has been scored by the modified T-score technique ($6\sigma/100$). The sum of these 20 scores constitutes the criterion score.

In addition to the validity requirement that each element must have been previously shown or must logically be expected to have had reasonable relationship to its factor, each element (1) must be easily administered, (2) must not require equipment which is expensive or difficult to obtain, (3) must be a desirable activity in its own right, and (4) must not consume too much time. The reliabilities of most of the items have been previously established in other studies, but for the purpose of this study the practical reliability of showing adequate correlation with the criterion is accepted as sufficient evidence that workers in the project can obtain measures reliable enough not to detract appreciably from the validity of the items. This is the quality which items accepted for army or college use must exhibit. More technical and meticulous measurement could be reasonably expected to increase reliabilities and subsequently validities, but the pragmatic criterion must prevail where large numbers and technically untrained leadership exist.

[4] From the lists it can be seen that some events reflect more than one factor.

PROCEDURES

Obtaining the data.—Over 900 Indiana University male students in the intensive "physical fitness program" were being measured as a procedure in that program. Use of these data made this study possible. The raw data for the 20 measures and their combinations were obtained on five consecutive days, during three of which the entire period was devoted to testing.

During the first full class period, activities were given which could be administered to the whole group in partner formation and recorded on individual record slips. Partners scored each other for the Brace test (Iowa Revision — 10 stunts), the Burpee test (performing a squat, front-support, squat, stand event as many times as possible within 10 seconds), and push-ups on the floor (starting in a front support position and keeping body straight, touching chest to floor and returning to straight arm front support position — repeating as many times as possible). Age was obtained to the nearest six months, height to the nearest inch, and weight to the nearest two pounds.

Squad leaders scored the events given during the second full period on squad cards which included records of the names and results for each pupil in the squad on all squad events. Squads were placed at different events and rotated in order from the parallel bars (where dips were performed), to the vertical jump (the distance between the reach and jump marks was measured in inches), to the high bar (on which chins were performed), to the standing broad jump (performed on mats and measured in inches), and to the parallel bars, until all squads have performed each of the four events.

Warm-up exercises were given at the beginning of the third period. Then two squads at a time throughout the period ran the 60-yard dash. Two rather well matched men of each squad ran at one time. A stop watch was used to clock the leading man in each pair. The second runner's time was determined by the number of zones he was behind the first runner. One-fifth of a second per zone was added to the time of the first runner to obtain the time for the second runner. Time was recorded in seconds and fifths of seconds.

The two-mile walk filled the entire fourth period and was executed on the quarter-mile track. The instructor started the class together and spotted the leaders and stragglers, so that when leaders overlapped the stragglers they could be identified and timed properly. Time was kept in minutes and seconds to the last five-second period. American Amateur Athletic Union rules were observed.

Warm-up exercises were given during the first part of the fifth period. These were followed by the 440-yard run. Squad organization was used. As many as 10 or 15 men could run at one time. As contestants crossed the finish line the time was called to them to the nearest second. Each man then gave his time to the recorder.

From the individual record slips and squad cards, all data were transcribed to master data sheets which contained the pupil's identification number, the raw scores on all events, and eventually the corresponding code numbers for these events. As soon as all data on

any set of events were recorded on these master data sheets, a Hollerith operator punched these data on the individual's Hollerith cards.

All data concerning each individual, whether on record slips, squad cards, master data sheets, or Hollerith cards, were numbered by a consecutive numbering machine to insure their accurate identification in recording, transcribing, punching, and computing.

The instructors in practically all classes were senior majors in physical education who were paid by the hour and followed a program outlined and supervised by a "program committee." While most of these young men were majors in the department, the teaching was their first teaching experience. It is reasonable to assume that class leaders or noncommissioned officers could have administered all events with similar directions and supervision, which included mimeographed standardized directions and pre-demonstrations.

In all instances the events were accomplished within a 34-minute class period and, on days when partial time was allotted to measurement, this time was preceded by calisthenics. Instructors, supervisors, and students rather uniformly considered the activities to be satisfactory for "physical fitness" purposes.

Mass-conducted activities of the first day of testing, including the Brace test, Burpee test, push-ups, age, height, and weight, were recorded on individual mimeographed slips of paper. Squad activities, including standing broad jump, chins, vertical jump, dips, 60-yard dash, and 440-yard run, were recorded on squad cards by the squad leaders. The records of the two-mile walk were placed on class rolls opposite each pupil's number as he finished. These records were later transferred to the squad cards by the instructors.

Computation of composite scores.—Two experienced measurements workers, two NYA workers, and two other paid assistants computed scores on (1) Classification Index I, (2) General Motor Cacapity, (3) General Motor Quotient, (4) Larson's Dynamic Strength Test, (5) Power I[5] (chins-plus-dips times vertical jump — all raw scored), (6) Power II[5] (chins-plus-push-ups times vertical jump — all T-scored), and (7) drop-off (time on 440-yard run divided by time on 60-yard dash) as soon as records came in from the class instructors. One person was given complete responsibility for the final recording of all raw scores and T-scores. When he indicated that all raw data were recorded from the 18 class sections involved, Hollerith code numbers were determined and later recorded by the "master data" clerk. When this clerk approved the completeness of all code records for any event, the master data code numbers were punched on Hollerith punch cards. This punching was under the responsibility of one worker, an experienced Hollerith operator, although the master data clerk was able to assist at times. This delegation of responsibilities made for greater accuracy in records.

Statistical treatment.—The first step in the statistical phase of the study was the computation of the means, variabilities, and intercorrelations of each element and the criterion (the sum of the 20 T-

[5] So called because of the multiplication of force times velocity which in the realm of physics produces a power factor.

scores). The essential calculations were all made on the Hollerith machine. Two hundred ten zero-order correlations were computed from which the matrix (Table II) was obtained. The purpose of this step was to validate measures for consideration for the final battery of items to be included in the Motor Fitness Index. The means and standard deviations describe the sampling obtained and give information to the physical education department at Indiana University concerning the evaluation of their program for "physical fitness."

Inspection of the matrix of zero-order correlations reveals the following significant facts: age, height, weight, and Classification Index I are inadequate measures of the criterion ($r = .231 \pm .03$, $.264 \pm .03$, $.236 \pm .03$, and $.264 \pm .03$, respectively), which would seem to indicate that these maturity and structure measures are not significantly related to motor fitness of the college age group. This conclusion has been borne out by several other studies of college men. Two indices, General Motor Quotient and drop-off (440-yard run time divided by 60-yard dash time), have correlations of $.088 \pm .03$ and $.230 \pm .03$, respectively. Such relationships are quite common in physical education studies when indices are compared with direct measures. The low correlations of Rogers' Physical Fitness Index with most physical measures are examples. The two-mile walk is the final item excluded from further consideration by reason of its low correlation with the criterion ($.280 \pm .03$).

Consideration of the elements with high and considerable relationships follows. The highest correlation with the criterion is that of Power II (r of $.831 \pm .01$), which is high by the standard for this study.[6] The Larson Dynamic Strength Test (weighted chins, dips, and vertical jump) correlates $.797 \pm .01$ with the criterion, which for practical purposes is also a high correlation. General Motor Capacity (weighted combination of Classification Index I, Burpee test, vertical jump, and Iowa Revision of Brace's Motor Ability Test) has a very "considerable" correlation ($.791 \pm .01$), but it is a complicated measure to score and fairly difficult to administer to large numbers. Power I is slightly more difficult to administer than Power II, measures approximately the same thing as Power II ($r = .829 \pm .01$), but has somewhat lower correlation with the criterion ($r = .768 \pm .01$) than has the accepted power test.

All of the above measures are combinations of three or more elements. The correlation of each with the criterion is somewhat spurious because, of their components, each appears in the criterion from two to four times. In consideration of its simplicity of computation from T-scores and the fact that it correlates highest with the criterion, Power II seems to warrant first consideration and Larson Dynamic Strength Test second place among the 20 items.

Vertical jump, standing broad jump, and Brace's Motor Ability

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[6] For the purposes of this study a previously accepted criterion of significance of correlations will be the standard: 0-.29 insignificant, .30-.59 low, .60-.79 considerable, .80-.89 high, and .90-1.00 very high. (Bookwalter, Karl W. *A Critical Evaluation of the Application of Some Existing Means for Classifying Boys in Physical Education.* Unpublished Doctor's dissertation, School of Education, New York University, New York, 1938. p. 122.)

TABLE II. INTERCORRELATIONS OF MOTOR FITNESS ITEMS AND TH E CRITERION

Item or event	Hollerith number	Hollerith number																				
		7	8	9	10	11	12	14	17	18	15	16	19	20	13	21	22	24	25	26	28	27
Age	7		—.039	.063	.018	.173	.188	.037	.135	.180	.179	.131	.150	.155	.140	.128	.167	.039	—.034	—.053	—.026	.231
Height	8			.455	.674	—.029	—.041	.156	.414	—.013	—.402	—.077	—.013	.058	—.075	.031	.119	.021	.085	.067	.096	.264
Weight	9				.756	—.012	—.007	.073	.408	—.077	—.239	—.112	—.080	—.102	—.062	—.551	.029	.027	—.041	—.047	.009	.236
Classification Index I	10					—.041	—.025	—.012	.456	—.084	—.170	—.159	—.015	.108	—.057	.053	.092	.002	.003	.045	.058	.264
Brace test	11						.277	.184	.365	.734	.316	.186	.446	.365	.337	.399	.473	.258	.300	.107	.122	.639
Burpee test	12							.272	.410	.515	.248	.235	.288	.310	.261	.289	.274	.249	.249	.133	.063	.440
Vertical jump	14								.650	.681	.328	.294	.729	.527	.354	.769	.589	.398	.366	.048	.135	.715
General Motor Capacity	17									.719	.276	.340	.562	.430	.369	.600	.548	.356	.315	.048	.128	.791
General Motor Quotient	18										.421	.427	.673	.577	.424	.673	.802	.407	.383	.061	.104	.688
Chins	15											.599	.673	.821	.585	.666	.416	—.723	.407	.246	.195	.597
Dips	16												.550	.783	.577	.590	.343	.367	.360	—.162	.040	.592
Larson Dynamic Strength Test	19													.958	.497	.832	.574	.400	.457	.138	.143	.797
Power I	20														.601	.829	.397	.413	.422	.249	.219	.768
Push-ups	13															.618	.405	.324	.352	.221	.218	.574
Power II	21																.544	.447	.420	—.227	.224	.831
Standing broad jump	22																	.291	.318	.106	.134	.712
60-yard dash	24																		.484	—.215	.357	.440
440-yard run	25																			.601	.388	.576
Drop-off	26																				.271	.230
2-mile walk	23																					.280
Mean		20.1	69.70	153.6	910.9	15.99	6.27	20.81	246.4	100.3	7.15	4.86	293.8	256.7	16.03	45.42	86.47	8.06	68.6	9.12	23.8	100.2
σ		1.94	2.88	19.66	30.6	2.92	1.03	2.94	14.4	7.5	3.18	3.27	62.1	137.6	6.66	25.65	8.13	.59	7.4	.57	2.6	33.4
Number of cases		808	808	810	810	810	800	710	712	712	694	708	706	707	808	705	708	690	673	601	660	552

Test (Iowa Revision) each has "considerable" correlation[7] with the criterion (.715 ± .01, .712 ± .01, and .639 ± .02, respectively). These correlations, while slightly spurious, are obtained singly and consequently are probably more real than those of the several combinations of these events previously evaluated.

The correlations of other single measures are: chins, $r = .597 \pm .02$; dips, $r = .592 \pm .02$; 440-yard run, $r = .576 \pm .02$; push-ups, $r = .574 \pm .02$; Burpee test (stand-squat-front support-squat-stand, repeated for 10 seconds), $r = .440 \pm .03$; and 60-yard dash, $r = .440 \pm .03$.

DESCRIPTION OF ELEMENT COMBINATIONS

The four highest correlations with the criterion measure were those of Power II, Larson Dynamic Strength Test, General Motor Capacity, and Power I. These correlations, respectively, were: .831 ± .01 (high), .797 ± .01 (high), .791 ± .01 (very "considerable"), and .768 ± .01 ("considerable"). Three of these measures were easily administered and were of such a similar nature that the hypothesis was drawn that the finally accepted measure of motor fitness should be of this type — power measures obtained from force and velocity elements. This hypothesis was further borne out by the "considerable" correlations of vertical jump ($r = .715 \pm .02$) and standing broad jump ($r = .712 \pm .02$) with the criterion. These are both velocity indices and simple measures. General Motor Capacity was disregarded, since it failed to meet the criterion of administrative simplicity.

The combinations used are of three types: (1) Larson weightings, in which substitutions are tried in the Larson test, (2) modified T-scores in combinations, and (3) raw scores in combinations. Table III shows the intercorrelation of all combinations and the criterion. In this table the initial letter in each factor, L, R, T, indicates that Larson weightings, raw scores, or T-scores, respectively, are employed to obtain the combined score. The parenthesized letters C, D, P, Bur, 440 are symbols for chins, dips, push-ups, Burpee test, and 440-yard run. The final letter in each factor, V or S, signifies that the sums within the parentheses were multiplied by the appropriate vertical jump or standing broad jump score, respectively. P_2 + Bur, P_2 + 440, and P_2 + Bur + 440 indicate that to the strength items (chins + dips) of the Power II measure (later titled the Indiana University Motor Fitness Index) were added the T-scores for the Burpee test, the 440-yard run, or both, after which the final sums were multiplied by the vertical jump T-scores.

The correlations found when the various combinations in each of the three types were correlated with the criterion were as follows:

Hollerith number	Combined events	r with criterion
Larson Weighted Combinations		
28	Chins plus push-ups plus vertical jump (push-ups modified T-scored, and weighted as dips in Larson's test)	.821 ± .01

[7] As judged by the standards for significant correlations in this study.

TABLE III. INTERCORRELATIONS OF MULTIPLE-ELEMENT COMBINATIONS AND THE CRITERION*

Factors	Hollerith number	Hollerith number													
		27	28	29	30	31	32	33	34	35	36	37	38	19	20
Crit.	27		.821	.704	.743	.707	.761	.744	.772	.783	.834	.844	.839	.797	.768
L(CP)V	28			.786	.780	.717	.826	.795	.775	.776	.850	.855	.846	.542	.802
L(CP)S	29				.724	.758	.834	.719	.781	.801	.687	.694	.673	.472	.754
R(CP)V	30					.901	.726	.791	.764	.831	.815	.791	.774	.308	.724
R(CP)S	31						.756	.754	.791	.871	.871	.699	.668	.501	.825
L(CD)S	32							.843	.856	.831	.697	.702	.718	.455	.794
T(CD)V	33								.857	.788	.775	.786	.759	.510	.937
T(CD)S	34									.915	.768	.770	.745	.471	.851
T(CP)S	35										.781	.691	.759	.457	.601
P_2+Bur	36											.931	.956	.513	.788
P_2+440	37												.927	.522	.789
P_2+440+Bur	38													.514	.768
L.D.S.	19														.958
R(CD)V	20														
Mean		100.2	255.64	216.44	49.44	203.63	263.84	25.68	51.18	52.03	77.30	78.25	103.25	293.8	256.70
σ		33.40	21.00	49.00	22.20	87.00	53.60	13.76	26.40	25.65	36.00	36.00	45.50	62.10	137.6
Number of cases		552	551	551	551	551	551	551	551	551	551	551	551	706	707

* See meanings of the abbreviations on page 12.

29	Chins plus push-ups plus standing broad jump (push-ups and standing broad jump modified T-scored, and weighted as dips and vertical jump, respectively, in Larson's test)	.704 ± .01
32	Chins plus dips on parallels plus standing broad jump (standing broad jump modified T-scored, and weighted as vertical jump in Larson's test)	.761 ± .01
19	Larson's original Dynamic Strength Test	.797 ± .01
Raw Score Combinations		
30	Chins-plus-push-ups times vertical jump	.743 ± .01
31	Chins-plus-push-ups times standing broad jump	.707 ± .01
20	Chins-plus-dips times vertical jump	.768 ± .01
Modified T-Score Combinations		
33	Chins-plus-dips times vertical jump	.744 ± .01
34	Chins-plus-dips times standing broad jump	.722 ± .01
35	Chins-plus-push-ups times standing broad jump	.783 ± .01
21	Chins-plus-push-ups times vertical jump (Power II)	.831 ± .01

Since Power II correlated higher with the criterion than did any of the other measures in the original battery, it was selected as the three-item measure for combination with other items for study. For combination with Power II, the Burpee test was chosen for two reasons: (1) it was a measure of agility and abdominal strength not directly measured in Power II, and (2) it had a correlation of .440 ± .03 with the criterion, which for a lone item merits consideration.

The 440-yard run had the highest correlation with the criterion of any of the endurance items, namely .576 ± .02. It seemed desirable to include a direct measure of endurance in the final battery provided that the validity increase warranted the additional administrative difficulty involved in its application.

The validity coefficients of the combinations of each and both of these items are indicated below.

Hollerith number	Combined events	r with criterion	Per cent of increase in relationship over Power II alone
31	Chins-plus-push-ups-plus-Burpee-test times vertical jump (all items modified T-scored, and treated as indicated)	.834 ± .01	.7
37	Chins-plus-push-ups-plus-440-yard-run times vertical jump	.844 ± .01	2.1
38	Chins-plus-push-ups-plus-Burpee-test-plus-440-yard-run times vertical jump	.839 ± .01	1.3

From these results it would seem that gains in effectiveness as a measure of motor fitness over Power II by the addition of the

Burpee test or 440-yard run, or both, are not commensurate with the additional administrative difficulty involved. It is finally concluded that, all things considered, Power II is the preferred index of motor fitness as measured in this study. Hereafter it shall be called the Indiana University Motor Fitness Index.

A further comparison of the Indiana University Motor Fitness Index with the previously established Larson's Dynamic Strength Test shows that the coefficient of validity of the latter is .797 ± .01, which indicates 4.7 per cent less relationship to motor fitness than the Indiana University Motor Fitness Index. In addition to this fact, the push-ups employed in the Indiana University Motor Fitness Index are appreciably simpler and more economical to administer than dips on the parallel bars, which are employed in Larson's Dynamic Strength Test. Finally, the simple modified T-scores on chins, push-ups, and vertical jump are more simple and understandable to the average user of tests than the weighted scores in Larson's test. It seems quite evident from the results of this study that the Indiana University Motor Fitness Index is to be preferred to Larson's Dynamic Strength Test as a measure of motor fitness, and there is reason to believe that it would be preferred under most conditions.

Full credit must be given to the author of Larson's Dynamic Strength Test for the contribution to the concepts and techniques which are employed in the present study. Further credit is due to the power concept of Howard Leigh MacCurdy[8] in his study of physical capacity, which led to the development of the Motor Fitness Index.

FINDINGS AND CONCLUSIONS

1. There is a need for an index of motor fitness.
2. The factors involved in motor fitness are strength, velocity, motor ability, power, endurance, and agility, in approximately this order of importance.
3. To be useful in present motor fitness programs, an index to motor fitness should be valid, easily administered, and of educational value as an activity in itself, and it should not require expensive equipment.
4. Age, height, weight, and combinations of these elements have low validity in a motor fitness criterion for college men.
5. General Motor Capacity has highly "considerable" validity in the assessment of motor fitness ($r = .791 \pm .01$).
6. General Motor Quotient, drop-off (time on 440-yard run divided by time on the 60-yard dash), and two-mile walk each has low validity in a motor fitness criterion.
7. Larson's Dynamic Strength Test seems to be improved by the substitution of push-ups on the floor for dips on the parallel bars.
8. The preferred index of motor ability as revealed by this study is the Indiana University Motor Fitness Index, formerly Power II, ($r = .831 \pm .01$).
9. When the Burpee test or the 440-yard run, or both, is added to the Motor Fitness Index, the results are more satisfactory statis-

[8] MacCurdy, Howard Leigh. *A Test for Measuring the Physical Capacity of Secondary School Boys.* H. L. MacCurdy, Bronxville, New York, 1933. p. 31.

tically than when the Index is used alone, but this improvement is overbalanced by the additional labor involved.

10. The utilization of chins-plus-push-ups times vertical jump with *raw scores* has definite validity as a measure of achievement in motor fitness ($r = .743 \pm .01$), although its use as a classifier probably would not be justified.

RECOMMENDATIONS FOR USE AND FURTHER STUDY

1. The sum of the modified T-scores on chins and push-ups multiplied by the T-score on the vertical jump in inches provides a valid, economical measure of the factors of strength, velocity, motor ability, power, and endurance of college age men. The correlation of this measure with its criterion is $.831 \pm .01$, which is "high" according to the standards for this study.

2. Norms for this measure should be set up for McCloy's Classification Index groups and for Cozens' Height-Weight Class Divisions for college age men.

3. Gains on this measure might reasonably be expected to reflect gains resulting from a more complete motor-fitness activity program. The total gains on the components of this measure over a five-month period of intensive motor fitness training at Indiana University were: chins, 26 per cent; push-ups, 25 per cent; and vertical jump, 15 per cent.

4. Chins-plus-push-ups times vertical jump in inches (all measures in raw scores) is a measure with "considerable" correlation with the criterion ($r = .743 \pm .01$) and might be employed as a second choice in the event that time and ability prevent the application of the preferred procedure.

5. There is reason to believe that a study should be made of the use of modified chinning (rear-lying angle-support by partner) as a substitute for the usual form in chinning. If this form could be employed, as it reasonably might, the test would be appreciably simplified and should be even more popular than the present measure.

6. A partial and multiple correlation study might be undertaken with the original data from this study to determine: (*a*) the relative contribution of the Motor Fitness Index to each of the essential factors in motor fitness; and (*b*) a possibly superior index from the weightings indicated by the regression equation for these items.

7. The Motor Fitness Index can be utilized as the primary and functional measure, with Classification Index I as the secondary and structural measure, in an administrative classification for college men. Previous studies by the senior author bear out this recommendation.

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THE INDIANA UNIVERSITY MOTOR FITNESS INDEX TEST MANUAL

KARL W. BOOKWALTER AND CAROLYN W. BOOKWALTER

THE Indiana University Motor Fitness Index, involving the sum of the T-scored chins and push-ups multiplied by T-scored vertical jump, should not be considered to be the best motor fitness index that might be obtained from existing measures. It is a valid measure of motor fitness and, in consideration of the criteria for its selection, it is a highly practicable measure.

It was chosen as a valid measure which (1) is worth while as an activity itself, (2) is easy to administer with technically untrained assistants, (3) is administrable in a minimum of time, (4) does not require expensive equipment, and (5) can be administered to large groups with facility.

This index can be (1) employed to measure achievement in a physical fitness or motor fitness program, (2) used as a functional primary administrative classifier (it should produce a high degree of homogeneity when Classification Index I is used as the secondary classifier for hulk and maturity), and (3) included in a battery of tests or measures for research purposes.

The Motor Fitness Index is a combination of the "power principle" employed in MacCurdy's Physical Capacity Index and the "dynamic strength principle" utilized in Larson's Dynamic Strength Test. It is superior administratively to MacCurdy's Physical Capacity Index, since it does not require the costly equipment of the latter test and is quicker to administer. The Motor Fitness Index is administratively superior to Larson's Dynamic Strength Test, since push-ups on the floor in the former are cheaper and easier to administer than dips on the parallels in the latter. Furthermore, the Indiana University Motor Fitness Index correlates .831 $\pm$ .01 with a varied and valid measure of motor fitness consisting of 20 items selected for their relation to the factors of strength, velocity, dead weight, motor ability, height, and endurance. These factors are themselves proved to be associated with successful performance in physical education activities. In comparison with this, Larson's test correlates .797 $\pm$ .01 with the same measure. Thus there is a difference between the two measures of 5 per cent in favor of the Indiana University Motor Fitness Index, or a relative gain of 12½ per cent.

DIRECTIONS FOR ADMINISTERING THE TEST

The Motor Fitness Index can be given in one 50-minute period to a large number of men (60 or more). The class should be divided into groups. One half of the class should be given the chins and vertical jump under their squad leaders. The other half should be re-divided into halves. One half of this latter group will do the push-ups while the other half records. The push-up groups will then exchange, the former recorders doing the push-ups which are recorded by the former performers. The two halves of the class will then exchange so that all get the chins, push-ups, and vertical jump.

The following individual Motor Fitness Index record card permits of comparisons with past records and with school or present norms.

RULES FOR INDIANA UNIVERSITY MOTOR FITNESS INDEX

1. The chins may be performed with any grip. No half credits are permitted and the chin must clear the bar on each pull-up. Arms must be fully extended on the return. No swinging or kicking is

allowed, although an assistant may steady the legs of the chinner. The chins must be executed regularly, without rest.

2. The push-ups are executed from a front support. The chest must touch the floor each time and the arms must be fully straightened on the return. The back must be kept straight. No partial credits are allowed, and the dips must be done regularly with no rest in between.

3. The vertical jump is made to a blackened plywood board suspended from a basketball backstop (five feet long and one foot wide). The jumper toes a line one foot in front of the board. The index finger is chalked with magnesium. The jumper reaches as far as possible with the heels kept on the floor and makes a mark on the board with the chalked finger. Next he executes three jumps vertically from a squat, making a mark each time upon the board. The distance from the top of the reach mark to the top of the highest jump mark is recorded as the vertical jump. This should be measured to the last quarter inch.

DIRECTIONS FOR SCORING INDIANA UNIVERSITY MOTOR FITNESS INDEX

Assume that the raw scores of John Doe are as follows:

Chins — 6 times
Push-ups — 18 times
Vertical jump — 18.25 inches

Referring to the "Scale Scores For Motor Fitness Index," on pages 20 and 21, we see that 6 chins earn a score of 44 points and 18 push-ups earn a score of 55 points. The sum of these two force items is 99 points. According to scale scores, a vertical jump of 18.25 inches gets 35 points. By multiplying the sum of the scale scores earned on the chins and push-ups (99) by the scale score earned on vertical jump (35), a product of 3,465 is obtained. This product is divided by 100 for simplicity and rounded to the nearest whole number. The resulting number, 35, is the Indiana University Motor Fitness Index for this individual.

INDIANA UNIVERSITY
Department of Physical Education for Men
Motor Fitness Index

Name ..... Section.....

Dates of tests								
	Scores							
Items	Raw	T-sc	Raw	T-sc	Raw	T-sc	Raw	T-sc
1. Chins								
2. Push-ups								
Sum of T-scores								
	To be multiplied by T-score of							
3. Vertical jump ..... which gives the								
4. MOTOR FITNESS INDEX								
Gains in percentage								
M.F.I. Classification (S,G,N,P,I) ...								

INDIANA UNIVERSITY SCALE SCORES FOR MOTOR FITNESS INDEX ITEMS
Modified T-scores (6σ/100)

Rank	Scale score	Raw score			Scale score	Total score
		Chins	Push-ups	Vertical jump		
SUPERIOR	100	17	36	29.75	100	122.42
	99			29.50	99	120.88
	98			29.25	98	119.34
	97		35	29.00	97	117.80
	96	16			96	116.26
	95		34	28.75	95	114.72
	94			28.50	94	113.18
	93				93	111.64
	92		33	28.25	92	110.10
	91	15		28.00	91	108.56
	90		32		90	107.02
	89			27.75	89	105.48
	88			27.50	88	103.94
	87		31	27.25	87	102.40
	86	14			86	100.86
	85		30	27.00	85	99.32
	84			26.75	84	97.78
	83				83	96.24
	82		29	26.50	82	94.70
	81	13		26.25	81	93.16
	80		28		80	91.62
GOOD	79			26.00	79	90.08
	78			25.75	78	88.54
	77		27	25.50	77	87.00
	76				76	85.46
	75	12	26	25.25	75	83.92
	74			25.00	74	82.38
	73				73	80.84
	72		25	24.75	72	79.30
	71			24.50	71	77.76
	70	11	24	24.25	70	76.22
	69				69	74.68
	68			24.00	68	73.14
	67		23	23.75	67	71.60
	66				66	70.06
	65	10	22	23.50	65	68.52
	64			23.25	64	66.98
	63				63	65.44
	62		21	23.00	62	63.90
	61			22.75	61	62.36
	60	9	20	22.50	60	60.82
	59				59	59.28
AVERAGE	58			22.25	58	57.75
	57		19	22.00	57	56.26
	56				56	54.66
	55		18	21.75	55	53.12
	54	8		21.50	54	51.38
	53				53	50.04
	52		17	21.25	52	48.50
	51			21.00	51	46.96

Rank	Scale score	Raw score			Scale score	Total score
		Chins	Push-ups	Vertical jump		
AVERAGE	50		16	20.75	50	45.42
	49	7			49	43.88
	48			20.50	48	42.34
	47		15	20.25	47	40.80
	46				46	39.26
	45		14	20.00	45	37.72
	44	6		19.75	44	36.18
	43			19.50	43	34.64
	42		13		42	33.10
	41			19.25	41	31.56
	40		12	19.00	40	30.02
POOR	39	5			39	28.48
	38			18.75	38	26.94
	37		11	18.50	37	25.40
	36				36	23.86
	35		10	18.25	35	22.32
	34	4		18.00	34	20.78
	33			17.75	33	19.24
	32		9		32	17.70
	31			17.50	31	16.16
	30		8	17.25	30	14.62
	29				29	13.08
	28	3		17.00	28	11.54
	27		7	16.75	27	10.00
	26			16.50	26	8.46
	25		6		25	6.92
	24			16.25	24	5.38
	23	2		16.00	23	3.84
	22		5		22	2.30
	21			15.75	21	.76
	20		4	15.50	20	.00
INFERIOR	19				19	
	18	1		15.25	18	
	17		3	15.00	17	
	16			14.75	16	
	15		2		15	
	14			14.50	14	
	13			14.25	13	
	12		1		12	
	11			14.00	11	
	10			13.75	10	
	9			13.50	9	
	8				8	
	7			13.25	7	
	6			13.00	6	
	5				5	
	4			12.75	4	
	3			12.50	3	
	2		0		2	
	1			12.25	1	

TEMPORARY NORMS FOR INDIANA UNIVERSITY MOTOR FITNESS INDEX FOR COLLEGE AGE MEN

The following norms are based upon 705 Indiana University men in the "physical fitness program." The group was composed of both beginning and advanced men in about equal proportions, and should be fairly representative. Norms based upon several thousands of cases and for different McCloy's Classification Index groups or Cozens' Height-Weight Class Divisions should be available later.

Per cent of total group	Class intervals	Ratings
7	85 and up	Superior
24	59-84	Good
38	33-58	Normal (Average)
24	7-32	Poor
7	6 or less	Inferior

According to these norms the hypothetical score, figured above to be 35, is average or fair. The class intervals for these norms are determined as follows: between $-.5\sigma$ and $+.5\sigma$, fair; above $+.5\sigma$ and up to $+1.5\sigma$, good; and above $+1.5\sigma$, superior. Similarly, all below $-.5\sigma$ but not below -1.5σ are poor, and all below -1.5σ are inferior. Reference to the scale scores for total scores in Indiana University Motor Fitness Index on pages 20 and 21 will reveal finer gradations for evaluating performance in this measure.

A List of Bulletins in the Field of Education, Indiana University

By KATHLEEN DUGDALE

The School of Education at Indiana University has published the following bulletins. All of these may be obtained from the University Bookstore for 50 cents postpaid unless otherwise noted.

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Proceedings of the Eleventh Conference on Educational Measurements. Vol. I, No. 3, 1925. 141 p.

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